

VEGETATION PRODUCTIVITY EQUATION COMPATIBILITY WITH SELECTED STATE ENVIRONMENTAL RECLAMATION LAWS AND REGULATIONS¹

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Abstract. Federal and State reclamation laws and regulations in the United States of America are becoming more precise and specific concerning evidence to support reclamation confirmation and subsequent bond release. Scientific methods to assess reclamation success are in their formative stages, with some investigators pursuing the development of efficient and effective assessment techniques. One analytic tool, the vegetation productivity equation, has been recently developed that may play an important role in future reclamation assessment activities. This paper examines current reclamation laws in seven States (North Dakota, Montana, Wyoming, South Dakota, Minnesota, Indiana, and Michigan) to determine their compatibility with the concept of vegetation productivity equations. Of the States examined for this study, five would require amendments to their reclamation regulations before the vegetation productivity equation would become a sanctioned assessment technique, and in one state empirical assessment techniques are not required. Only in South Dakota would vegetation productivity equations be compatible with existing regulations, providing review agencies accept the assessment technique as valid. This incompatibility with current reclamation regulations does not mean that vegetation productivity equations are intentionally being excluded from assessment methods; rather, vegetation productivity equations are still a new technique that has not yet been incorporated into the reclamation regulation fabric. While vegetation productivity methods may be eventually adopted in several States, reclamation regulations will require amendment before they can be fully employed.

Additional Key Words: natural resource policy, environmental law, landscape planning, ecological modeling.

Introduction

Reclamation laws and regulations in North Dakota require surface mine coal operators to reclaim the postmining landscape to a condition able to support vegetation growth that is equal to or better than the premining landscape situation. Operators must quantitatively demonstrate that the postmining landscape has been effectively reclaimed. The quantitative procedures employed to substantiate reclamation effectiveness are evolving and being improved through a collaborative effort between governmental regulators and policy makers, surface mine operators, the scientific community, and the public. This paper examines the current quantitative approaches, primarily the Cropland Reference Area Standard and the Soil Conservation Service (SCS) Cropland Technical Standard, in comparison to the prospects presented by the Vegetation Productivity Equation Method, a new quantitative approach that may be a candidate for eventual inclusion as a standard evaluation technique.

Federal involvement in surface mine reclamation is a relatively recent activity, starting with proposed legislation in the 1940s and culminating in significant legislation in 1977. Workman (1987) states that national legislation was necessary because many States were hesitant to develop a regulatory system that might discourage industrial activity within the State and encourage industry to seek production in other States. Without a regulatory system, surface-mined lands were often abandoned and not reclaimed. Thus, Federal legislation was paramount to have an economically equitable situation between the states and to enforce reclamation activity.

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Simpson (1985) reviews the chronology of applicable environmental movements and Federal legislation leading to the Surface Mining Control and Reclamation Act (SMCRA) of 1977 (Public Law 95-87), signed into law by President Carter. Dunlap (1976) reviews the legislative history of this Act, noting that 1975 legislative activity formed the precedent to the 1977 SMCRA. Scheter (1980) reviewed the historical background and effects of the 1977 act. Munshower and Judy (1988) state that the SMCRA of 1977 defined the expectations associated with the reclamation of surface mined coal landscapes. They note, "... legislation did not intend to prevent surface mining for coal, but rather attempted to convey society's recognition that reclamation must be an integral part of any coal surface mining activity. In effect, the U.S. Congress was reflecting this desire for protection from impacts of such development and the need for reclamation." As required by the National Environmental Policy Act of 1969, the Federal Government prepared an Environmental Impact Statement (EIS) of the policies and regulations concerning the 1977 SMCRA, with the Office of Surface Mining (OSM) as the lead agency conducting the EIS. The OSM (1979) EIS also identifies the purposes of the Act. The SMCRA of 1977 gave each State the primary responsibility for regulating surface mining and reclamation. This regulatory approach is called "State Primacy" (Workman 1987). Workman (1987) remarks that Congress recognized the need for State administration to address a diversity of terrain, climate, biology, geochemistry, and other physical attributes of coal mining areas. Note the emphasis upon coal and not other surface mines such as sand and gravel or kaolinite mines. The State primacy approach is not without criticism. Lucas (1987) ascertains that there is much confusion in a Federal oversight situation where surface mine operators have been subjected to the confusion of a dual agency regulation system (State and Federal). Cardwell (1987) maintains that except for lawyers, everyone (land owners, operators, State regulators, Federal regulators, and environmentalists) has been a loser. Despite problems, Federal legislation exists that attempts to maintain a set of minimum reclamation standards for surface-mined coal lands across the United States. This legislation entrusts the development and enforcement of regulations to each State. Dernbach (1986), Udall (1979), and Vestal (1988) also provide insight into the effectiveness of and retrospective perspectives to, the 1977 SMCRA.

Discussion

North Dakota Rules and Regulations

In response to the SMCRA of 1977, the State of North Dakota charged the Public Service Commission (PSC) with regulation and enforcement of surface mining and reclamation within the State. Hagen (1974) presents a pre-SMCRA of 1977 perspective concerning North Dakota reclamation law. The laws examined in this study governing surface mining and reclamation operations were published by the PSC in 1989. These laws include three statutes: Surface Mining and Reclamation Operations, Surface Owner Protection Act, and the Exploration Data. Essentially, the Surface Mining and Reclamation Operations statute addresses the permitting and inspection process. The intent of this statute (PSC 1989) includes recognizing the impact of surface mining, acknowledging the importance of coal mining, the importance of regulation, the protection of the public tax base, and the importance of inspections. The statute addresses the importance of restoring the landscape so that it is capable of supporting premining land-uses, including industrial, commercial, agricultural, residential, recreational, or public facilities. Also, the statute describes the protection of prime farmland (including soil horizon protection), backfill characteristics, topographical requirements, erosion control obligations, and hydrological requirements. In addition, on page 38 of the published statute (section 38-14.1-24,(17)), the PSC (1989) stresses the importance of maintaining soil productivity for vegetation growth. This philosophic position in the statute and the background history of the SMCRA of 1977 should provide insight into the origins and requirements for quantitative reclamation approaches in North Dakota. Complementing the statutes, the State of North Dakota has written "Rules Governing the Reclamation of Surface-Mined Lands" (PSC 1990). These rules describe in greater detail the requirements governed by the law, including performance standards for suitable plant growth, the issuance of performance bonds, backfilling and grading, revegetation, prime farmland requirements, and even the development of fish and wildlife habitat. Finally, the PSC (1988) has published "Standards for Evaluation of Revegetation Success and Recommended Procedures for Pre- and Postmining Vegetation Assessments." This document describes in great detail the allowable methods and techniques that are permissible to demonstrate that the reclamation work has been in compliance with the law so that performance bonds can be released. The document states--

According to NDAC 69-05.2-22-07(4)(b), "crop production from the permit area shall be equal to or greater than that of the approved reference area or standard with ninety percent statistical confidence for the last two consecutive growing seasons of the responsibility period." For prime farmlands, North Dakota rules require equal or greater productivity in each of the last three consecutive growing seasons of the responsibility period.

Notice that the document mentions a desired confidence level associated with the determination. In other words, to determine the soil productivity of the reclaimed landscape, inferential statistical procedures are mandated. Essentially there are two allowable techniques to determine the 90 % confidence level: the Cropland Reference Area Standard and the Soil Conservation Service (SCS) Technical Reference Standard.

Cropland Reference Area Standard. This approach employs an undisturbed parcel of land containing the same soil series as the premining soil profile. Crops are grown on the postmining soil and on the reference area site for 2 years (or 3 years for prime farmland). If the premining site contained more than one soil profile type, each disturbed profile must contain a corresponding reference profile from the same series. The PSC (1988) describes the mathematical procedures to employ to generate a weighted average yield from a site with multiple premining soil series.

SCS Technical Reference Standard. The second approach utilizes SCS soil survey data to generate the unadjusted premining crop yield standard to which the postmining soils are compared. The unadjusted yield is based upon climatic averages and can be adjusted using correction methods described by the PSC (1988).

For both techniques, the PSC (1988) describes the sampling procedures to conduct the statistical tests. The procedures detail the formula to determine the number of samples required in order to collect the observations. In addition, the PSC prescribes the allowable methods to measure vegetation productivity. The PSC (1988) also prescribes the type of statistical analysis to be employed in the comparison. The statistical method is the one-tailed Student t-test. Consequently, the State of North Dakota has a very descriptive and prescriptive set of laws, standards, methods, and statistical procedures to evaluate the capability of the landscape in a reclaimed condition. However, these approaches are not without criticism.

Concerns About Existing Approches

Until recently, the only method to determine the agricultural suitability of reclaimed surface mine soils (findings of reclaimability) was to grow crops on the reclaimed land and compare plant growth with that in reference areas or with existing SCS productivity data. The method has been in existence and employed for only a decade, so it is still a relatively novel approach and may be considered still in its formative stages. This approach has some severe limitations (Doll and Wollenhaupt 1985), especially concerning the extended length of time required to conduct the postmining reclamation evaluation and the inability of the approach to assist in the premine planning and design process. The method is considered relatively costly. Another problem with the approach is the effect upon the variation of the measured productivity values of uncontrollable environmental factors such as rainfall, hail damage, and insect damage. Reference areas may receive a key burst of rainfall from a thunderstorm that increases plant productivity while only a few hundred yards away no rainfall is recorded; conversely, a hail storm damaging the crops on the reclaimed site may not damage a nearby reference area. While the SCS Technical Standard approach can account for yearly variations in rainfall, there are presently no correction factors for hail or insect damage. Thus the method is not infallible and may require further field trials before an operator successfully demonstrates reclamation achievements. In addition, the cropland reference area and technical reference area approaches are *post hoc* evaluative methods, meaning that they offer little premining reclamation assessment and no corrective solutions. Once a soil has been placed in its planned reclaimed area configuration, changing or correcting a soil profile can be extremely costly. The reference approaches only confirm an outcome; they do not assist in providing information that may lead to successful reclamation results. The shortcomings of the reference area approach have resulted in the call for new quantitative measures (Walsh 1985).

Vegetation Productivity Equation Method

Essentially, reclamation research teams and individuals in the United States have attempted to build a reclamation equation that would predict average plant growth for a variety of vegetative crops based upon soil characteristics. Neill (1979) and Doll and Wollenhaupt (1985) were notable investigators who first suggested the mathematical composition of these models. The implied future advantages of these models include the application of the equation during the premining planning stages to predict optimum soil profile configurations for maximum plant growth at minimal reclamation costs, numerical prediction of the reclaimability of the landscape using soil parameters and the potential to apply reclamation equations to other forms of landscape disturbance such as construction activities. Several factors inhibited the instant development of such equations. First, to develop these models would require extensive data, meaning the collection of soil parameters (pH, bulk density, hydraulic conductivity, etc.) for a wide variety of soils and growing several types of crops (grains, vegetables, trees, and grasses) on these soils through diverse environmental conditions (drought, normal, and wet years). Second, to develop the model, one had to be versed in advanced statistical methods (multivariate procedures such as Principal Component Analysis). Burley (1988) and Burley, *et al.* (1989) published the first highly predictive reclamation model (Equation 1) by combining the fieldwork of the Soil Conservation Service and applying advanced statistical methods. This model was developed for seven agronomic crops in Clay County, Minnesota. In addition, Burley and Thomsen (1987) published the methodology to produce reclamation productivity models. Since that time, Burley (1991) has developed a productivity model applicable to both woody plant and agronomic crops, a productivity model for sugarbeets (Burley 1990), a paper describing the application of these procedures for reclamation specialists (Burley and Thomsen 1990), the development of two equations for a Florida case study (Burley and Bauer 1993), and a recent overview of issues concerning the equations (Burley 1992).

$$\begin{aligned} \text{PLANTS} = & .6206 + (-1.1805 * ((\text{HC} - 3.9296) / 4.0030)) + (-0.3575 * (((\text{SL} - 3.0000) / 4.6810) ** 2)) \\ & + (-1.9375 * ((\text{BD} - 1.3584) / 0.2644) * ((\text{FR} - 0.9075) / 3.4929)) + (-2.3420 * ((\text{EC} - 2.526) / 1.0947) * ((\text{FR} - 0.9075) / 3.4929)) \\ & + (1.2424 * ((\text{OM} - 3.9512) / 0.6638) * ((\text{EC} - 2.5269) / 1.0947)) \end{aligned} \quad (1)$$

where: $R^2 = 0.7399$, PLANTS = predicted productivity score, HC = hydraulic conductivity, SL = % slope, BD = bulk density, FR = % rock fragments, EC = electrical conductivity, OM = % organic matter

While Burley and colleagues have demonstrated that it is possible to build highly predictive reclamation models, the model presented in Equation 1 and similar models developed by Burley are applicable only to Clay County, Minnesota. However, as data concerning soil productivity are accumulated, future models applicable to large regions of the United States and to large regions in other countries may be created (although this process may take several generations of investigators to develop these models). Productivity equations have one similarity to the SCS Technical Reference Area Approach. The equations are generated from SCS data published in SCS County Soil Surveys, meaning that they are generated from a source acceptable to the PSC. The productivity equations are applicable to statistical sampling procedures approved by the PSC. Postmining soils can be sampled in accordance with the sample size determination techniques recommended by the PSC for crops but applied to soil sample sizes. Based upon the variables in a given productivity equation, the measured soils can generate a prediction of soil productivity. In addition, the soil samples can be compared using the Student t-test as recommended by the PSC (1988). The productivity equations are congruous to the soil weighting procedures described by the PSC (1988).

While the above paragraphs describe the suitability of productivity equations in evaluating the reclamation effectiveness of disturbed lands, the equations may also have some incompatibility problems. The first problem is that presently no productivity equation has been generated or compared to known yields on reclaimed soils. The models have been generated with strictly undisturbed soils. Before any reclamation productivity equation is accepted by any regulating authority, the agency needs to have sufficient evidence that these models predict the productivity of disturbed soils. Second, the equations are generated without the introduction of variables encountered in disturbed

soils but not encountered in existing undisturbed soils. For example, the models do not consider soils with toxic materials such as high levels of selenium or boron (Williams and Schuman 1987). Therefore, to apply these equations, the reclaimed soils cannot contain toxic materials beyond the boundaries of the soil profiles studied.

Other State Laws

The following discussion describes selected State laws and environmental issues pertinent to vegetation productivity reclamation. Montana, Minnesota, and South Dakota were selected because of their adjacency to North Dakota. In addition, Wyoming, Indiana, and Michigan were selected for examination as a second tier of States radiating from North Dakota. No other States or Canadian provinces were selected.

Montana. The State of Montana contains numerous coal deposits on the Northern Great Plains suitable for surface mine extraction. As in North Dakota, the State laws of Montana indicate a concern for restoring agricultural productivity after surface mine operations. The Montana State Code (State of Montana, 1985:Title 82, Minerals, Oil, and Gas. Chapter 4. Reclamation Minerals- Coal & Uranium: Part 2, 82-4-232-6-ii-B) declares no reclamation bond will be released, "... before soil productivity for prime farm lands to which the release would be applicable has returned to equivalent levels of yield as nonmined land of the same soil type in the surrounding area under equivalent management practices, as determined from the soil survey." This statement indicates the importance of determining premining soil productivity through such documents as soil surveys and then demonstrating that the postmining landscape can produce similar productivity values. To develop the rules concerning the assessment of postmining agricultural productivity, the State of Montana has mandated that the Board of Land Commissioners shall define the rules governing reclamation assessment (State of Montana 1985:82-4-233). This board shall define the rules for segregation of soil horizons, grading, and revegetation (State of Montana 1985:82-4-232-3). Part 3 (State of Montana 1985:82-4) describes the laws governing surface mines extracting metallic ores. Part 4 (State of Montana 1985:82-4) describes the laws pertaining to the reclamation of lands mined for bentonite, clay, scoria, phosphate rock, and gravel. The code acknowledges that acceptable postmining landuses include forestry, pasture, orchard, cropland, residence, recreation, industry, and wildlife habitat. Reclamation plans are subject to annual review and modification by the Board of Land Commissions to reclaim the land to a productive use. The State of Montana has developed considerable administrative rules governing coal reclamation, including the necessity for baseline vegetation productivity information and special application requirements for prime farmlands (Montana 1990:26-468 to 26-473, 26-488 to 26-490). According to the State of Montana (1990:26-597 to 26-599), there are several allowable monitoring methods to demonstrate revegetation success. These methods include the reference area comparison and the technical standard approach derived from historical data (similar to North Dakota's technical standard approach). For revegetation parcels less than 100 acres in size, U.S. Department of Agriculture or U.S. Department of the Interior technical guides may be employed. On prime farmlands, the crop with the greatest rooting depth must be one of the reference crops employed for reference area comparisons and monitoring (Montana 1990:26-642), with "at least at the 10% level of significance using statistically appropriate sampling techniques approved by the department in consultation with the Montana state office of the U.S. soil conservation service." (Montana 1990:26-643). For trees and shrubs, density and mortality data are employed to evaluate reclamation success (Montana 1990:26-602). While the State of Montana does not specify the mathematical methods required to demonstrate vegetation reclamation success, it appears that Montana's reclamation rules and regulations are similar in intent to North Dakota's rules and regulations. Montana's reclamation rules and regulations may accommodate productivity equations as a method to evaluate reclamation success, provided that the State of Montana and the Montana State Office of the U.S. Soil Conservation Service approve the methodology in advance of its application.

South Dakota. The State of South Dakota has developed the South Dakota Mined Land Reclamation Act (South Dakota 1983, 13A:418-446). South Dakota legislators have decided that the minerals covered by this Act include all organic and inorganic minerals except water, oil, gas, sand, gravel or rock to be crushed and used in construction, pegmatite minerals, and limestone, sand, gypsum, shale, or iron used in the process of making cement (South Dakota 1990b). Essentially, operators must submit a plan, and the plan must be approved before mining proceeds. According to the laws, reclamation plans that propose installation of vegetation related to a specific postmining

landuse requiring vegetation must select suitable tree species and appropriate seeds pertinent to the chosen postmining landuse (South Dakota 1983, 13A, title 45-6B-45). However, defining appropriate or suitable material can be an ambiguous task open to debate and varying opinion. Therefore, the State of South Dakota (1990:13A:title 45-6B-81) has authorized the Board of Minerals and Environment to promulgate requirements for surface mining and reclamation. ARSD 74:29:07:06 (State of South Dakota 1988) addresses reclamation standards. While these standards may not be as specific as North Dakota's rules governing revegetation, South Dakota's standards state "The applicant must develop methods and procedures for revegetation which incorporate reference areas, baseline data comparisons, or other procedures to determine postreclamation revegetation success," (State of South Dakota 1988:37), meaning that productivity equations are not necessarily excluded from consideration as a method to demonstrate reclamation success. For postmining landscapes that will contain cropland, "reclaimed land must have the capability of meeting or exceeding the premining crop production of the affected land or of the reference area, if used," (State of South Dakota 1988:44), another requirement facilitating the use of productivity equations. In addition to successfully implementing the development of desired vegetation, the State of South Dakota is concerned with the prevention of noxious weed establishment. The State of South Dakota recognizes a broad range of postmining landuses including forested lands, rangeland, agricultural land, wildlife habitat, recreational lands, industrial use, housing, and future mineral exploration on the site. Besides the landuses that predominantly contain vegetation, other postmining landuses may include the establishment of vegetation and could employ productivity equations. The State of South Dakota has a unique natural resource, the Black Hills, which are mined for their gold and silver. This area is an important visual, aesthetic and recreational resource. To protect the resource, the State of South Dakota governs the activities of large gold and silver mining operations. Vegetation is related to surface mining in the Black Hills of South Dakota because the visual experience within the Black Hills includes vegetation. Therefore the establishment of woody vegetation and native herbaceous plants is an important consideration when preparing a reclamation plan for silver and gold mining operations. The State of South Dakota also requires the reclamation of drill sites employed in mineral exploration (South Dakota 1990c:9-10), and in sand, gravel, and construction aggregate mining (South Dakota 1990d:2). Both activities could employ the use of productivity equations. While the State of South Dakota's reclamation rules and regulations may not be as stringent as those of North Dakota, the intent is similar in both States. South Dakota appears to have addressed a broad range of landscape disturbance activities that may require revegetation, giving the operator flexibility under some circumstances in selecting postmining landuses and in demonstrating reclamation success. The key to South Dakota's landscape reclamation success appears to be identified with the permitting process and the requirement that reclamation must meet the revegetation needs of the postmining land owner, often a South Dakota citizen.

Minnesota. Unlike North Dakota, Minnesota contains little coal, and none of it is being mined. Instead, Minnesota has iron ore and taconite mines, sand and gravel mines, quarries, kaolin clay mines, peat mines, and a great potential for nonferrous metallic mineral mines. The metallic mineral mines are governed by Minnesota State Law 1969 C. 774-1, effective 28 May 1969, which was amended by legislation in 1983, C. 270-1 through 4, effective 7 June 1983, to address the reclamation of land subjected to the mining of metallic minerals and peat (Minnesota 1977, 1991). The Minnesota Department of Natural Resources is given authority to write rules concerning the reclamation of metallic-mined and peat-mined lands. Quantitative vegetation productivity equation methods for demonstrating reclamation effectiveness are not required by the State of Minnesota; however, Minnesota does require vegetation standards, of 90 % ground cover on all iron ore and taconite lands that have not been disturbed for 3 years (Minnesota Department of Natural Resources 1980:5703). The Minnesota Department of Natural Resources (1993) has adopted rules for nonferrous metallic minerals. These rules contain reclamation revegetation requirements similar to those for iron ore and taconite mines and facilities. On peatland, the Minnesota Department of Natural Resources (1985:6) states, "During the fourth and fifth year following initiation of revegetation, a vegetated reclaimed area shall have a 75 percent live vegetative cover comprised of wetland or typical peatland species that are either planted or naturally occurring. The vegetation shall be self-sustaining, and either regenerating or in a stage of natural succession. Cover estimates of revegetation shall be measured by standard procedures approved by the commissioner for assessing ground cover and productivity." Revegetation activities on peatlands are required to be compatible with the postmining landuse and surrounding landuses. In Minnesota, local governments (municipalities, townships, and counties) can develop zoning and permitting processes that require bonding and evidence of reclamation success.

While these local governmental agencies have sometimes addressed the permitting process associated with surface mining in their planning and zoning codes, there appears to be no strong concern for stipulating quantitative evidence for demonstrated reclamation success. It appears as though Minnesota's revegetation rules and regulations are not as strenuous and exacting as North Dakota's revegetation rules and regulations; yet satisfactory reclamation has been achieved under Minnesota's system. While quantitative vegetation productivity assessment (other than percent cover) may not be required in Minnesota, vegetation productivity equations could potentially be employed to develop reclamation plans.

Wyoming. Wyoming contains substantial coal deposits suitable for surface mining. During the formative development of Wyoming's current reclamation regulations, Munshower and Judy (1988) note that in 1988 Wyoming was in the process of developing criteria to establish overburden suitability. These guidelines are intended to further clarify regulations. The guidelines are summarized in a table presented by Munshower and Judy (1988). The table lists overburden soil parameters that can affect revegetation success and development including: pH, electrical conductivity, percent saturation, texture, sodium absorption ratio, selenium, boron, nitrate and nitrogen, molybdenum, copper, lime, acid-base potential, lead, and arsenic. This approach is based upon the checklist method of analysis where one assumes that as long as each parameter is within an acceptable range, the suitability of the overburden is achieved. This proposed approach (a checklist approach) is quite different from the approach taken by the State of North Dakota. Eventually, a more empirical assessment approach, similar to that of North Dakota, was adopted. The problem with any checklist approach is that there will be no direct physical evidence of the probable suitability of the soil. Nevertheless, this approach is cost effective, requiring relatively simple sampling of the soil to determine the soil's ability to support vegetation. For the State of Wyoming, soil properties, appropriate for a checklist, are described in "Chapter IV: Environmental Protection Performance Standards" (Wyoming Department of Environmental Quality 1989) but are not as exacting as those checklist properties described by Munshower and Judy (1988). In contrast to the checklist method, appendix A of Wyoming's Department of Environmental Quality's document describes vegetation sampling methods and reclamation success standards for surface coal mining operations that are similar in detail (specific equations, reference area approaches) to North Dakota's regulations. It appears as though the State of Wyoming adopted a more quantitative approach, rather than following the proposed checklist approach. Finally, in an inspection of Wyoming's reclamation regulations, vegetation productivity equations are not yet part of the accepted methods for assessing reclamation success.

Indiana. The State of Indiana has extensive coal deposits suitable for surface mining. Indiana has enacted legislation to govern the reclamation of coal, clay, shale, and oil shale (Indiana 1990). The Director of Soils and Minerals must approve revegetation plans. Legislation requires that the A and B horizons of prime farmland must be preserved and replaced on the postmining landscape. In addition, the surface of the land must be graded in a uniform manner (Indiana 1990). *Hodel vs Indiana*, 1981, 101 S.Ct. 2376, 452 U.S. 314, 69 L.Ed. 2d40 (Indiana 1990) is a pertinent court case concerning prime farmland reclamation. The ruling decreed that "Prime farmland provisions of Surface Mining Control and Reclamation Act did not on their face, deprive property owner of economically beneficial use of his property without just compensation in violation of the Fifth amendment. Id. 'Prime farmland' and approximate original contour provision of Surface Mining Control and Reclamation Act did not violate the equal protection or due process guarantees of Fifth Amendment. Id." (Indiana 1990). While the State of Indiana has extensive coal resources and surface mine operations, specific revegetation monitoring programs and assessment methods are not stipulated. Instead, a practical approach is utilized, where topsoil horizons are replaced in land that was formerly on prime farmland.

Michigan. While the State of Michigan does not have extensive surface-mined coal lands, the State does address the reclamation of these lands in P.A. 1970 No. 92 sections 425.181 et seq. (Michigan 1978). The surface mine operator must submit plans for approval for coal, gypsum, stone, and metallic ore surface mines (excluding clay, gravel, marl, peat, or sand surface mines). In 1982, the State of Michigan created the Michigan Surface and Underground Mine Reclamation Act, P.A. 1982, No. 303, effective 12 October 1982 (Michigan 1990a), "An Act to regulate the mining of coal..." (Michigan 1990a:187-224) including the reclamation of abandoned mined lands. Article 3 of the Act addresses the permitting process with specific concern for an agricultural impact statement describing the boundaries,

area affected in acres, anticipated future effect, and anticipated time to restore the land (Michigan 1990a). Article 4 of the Act describes performance standards. These standards specifically address the management and postmining reconstruction of the A and B soil horizons and soil toxicity. However, no quantitative procedures addressing vegetation productivity are described in the performance standards. Michigan has an extensive sand dune system, and the State has enacted legislation to protect this resource, the Sand Dune Protection and Management Act, P.A. 1976 No. 222, effective 31 March 1977 (Michigan 1990b). This legislation was amended by P.A. 1989, No. 146-1-Chapter 2 Sand Dune Mining. Essentially, these laws are intended to protect Michigan's scenic sand dune resource; however, portions of these laws are slated for automatic sunset legislation, meaning they are to be repealed in 1995 (Michigan 1990b). In 1995 the State of Michigan will have to decide whether to continue the laws, allow the laws to be repealed, or amend the laws with new legislation.

Summary and Conclusions

Each State examined in this study has a slightly different perspective concerning the reclamation of surface mined lands. Minnesota, South Dakota, and Michigan all have special landscape environments that each State has decided require special legislation. While North Dakota is specifically concerned about preserving the vegetation productivity of the land, some States are less concerned about demonstrating quantitative vegetation productivity. These States may list performance standards for reconstructing the soil profiles. They may also use checklist procedures and surface mine regulation strictly through the permitting and review process by citizens and experts. Productivity equations appear to be compatible with the SMCRA of 1977, the statutes of the State of North Dakota, and the regulations prepared by the PSC. However, the PSC (1988) document "Standards for Evaluation of Revegetation Success and Recommended Procedures for Pre- and Postmining Vegetation Assessments" will require amendment if these equations are to become an approved method to assess postmining soil productivity. The amendment process would begin by the scientific reclamation community and the PSC technical staff favoring the adoption of such an approach. Productivity equations may not yet be pertinent to the reclamation laws and regulations in other States. However, reclamation regulations may be still undergoing formative development, meaning that the use of productivity equations may eventually be widespread and incorporated into the rules and regulations governed by State reclamation boards.

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